Evaluation of the Emission, Transport and Deposition of Mercury, Arsenic, and Fine Particulate Matter from Coal Based Power Plants in the Ohio River Valley Region

Funded by the National Energy Technology Laboratory
United States Department of Energy

Partners

Advanced Technology Systems

Argonne

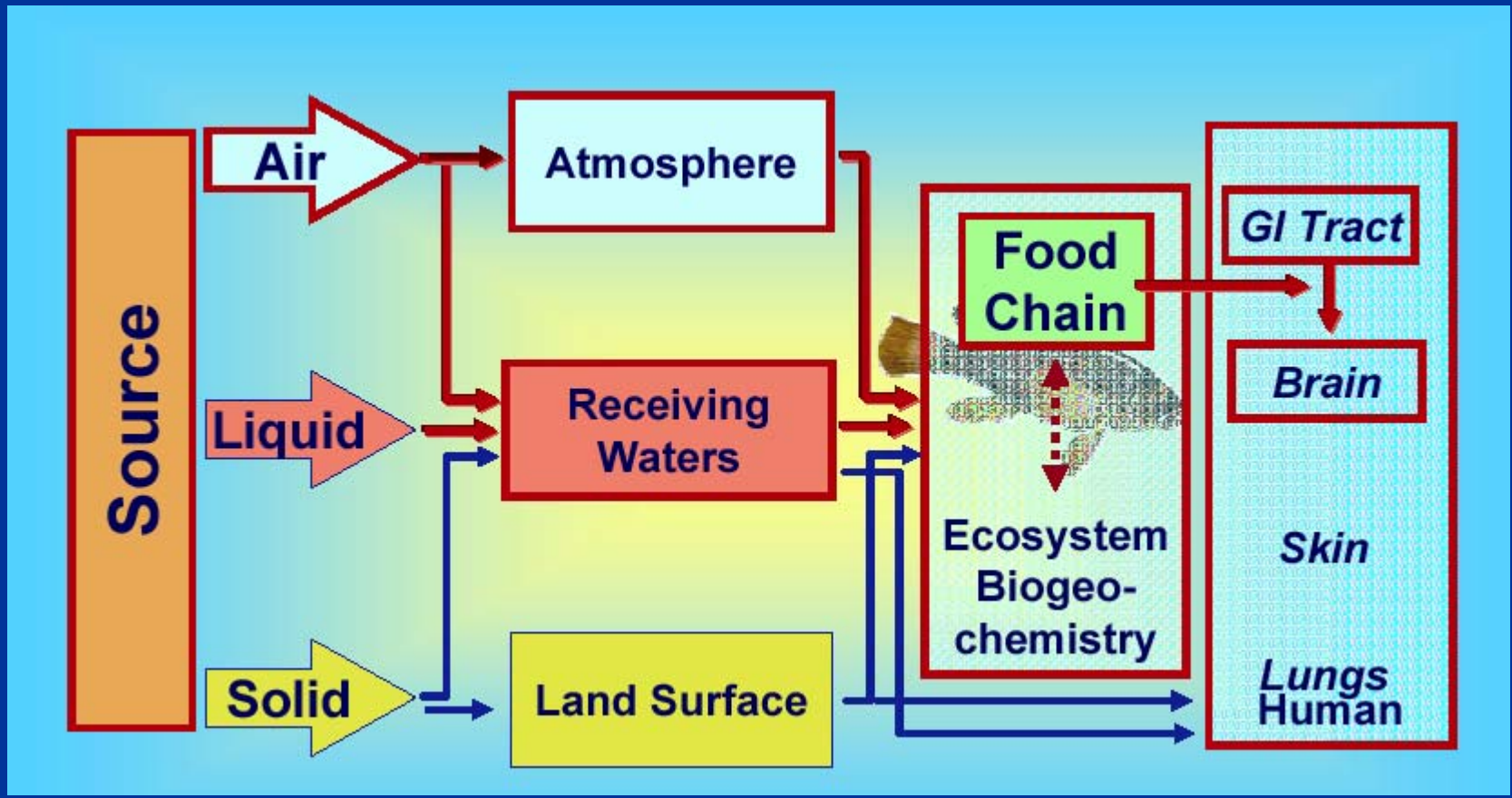
Atmospheric and Environmental Research

Consol Energy

Ohio EPA

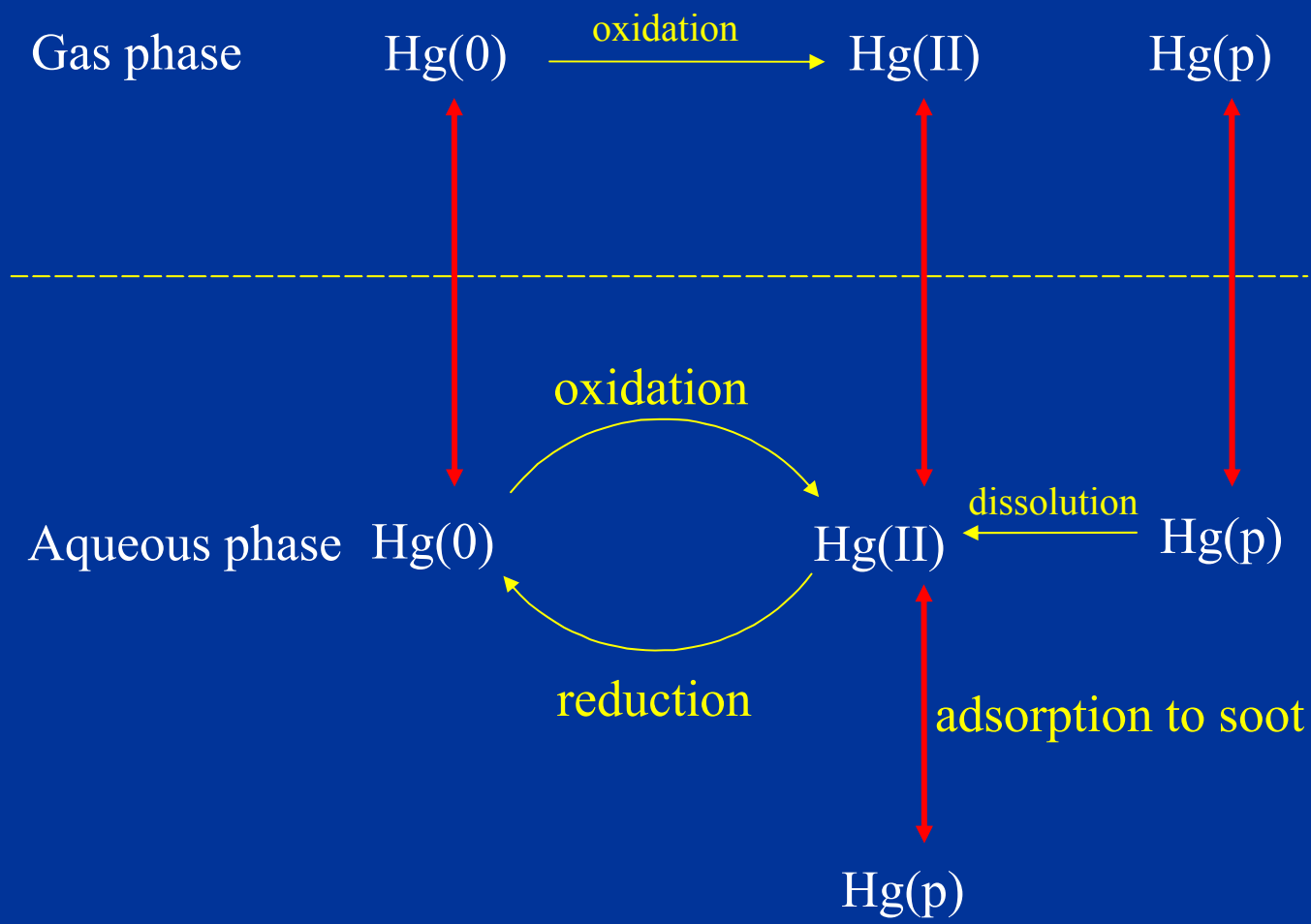
Ohio University

Potential Toxic Exposure in Humans
(major pathways are in red)

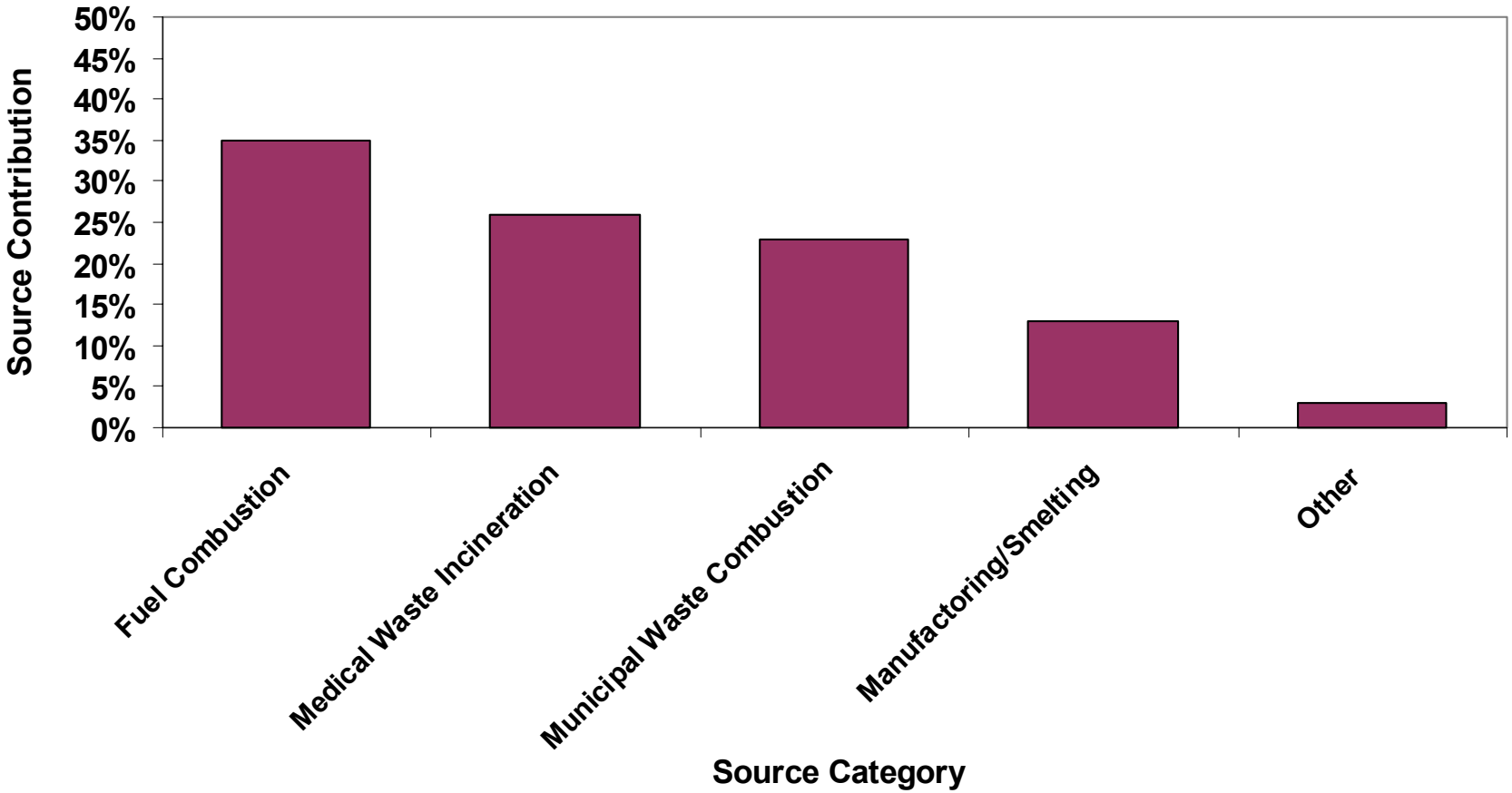


Source: Leonard Levin, Valuing Externalities Workshop, Feb 2003

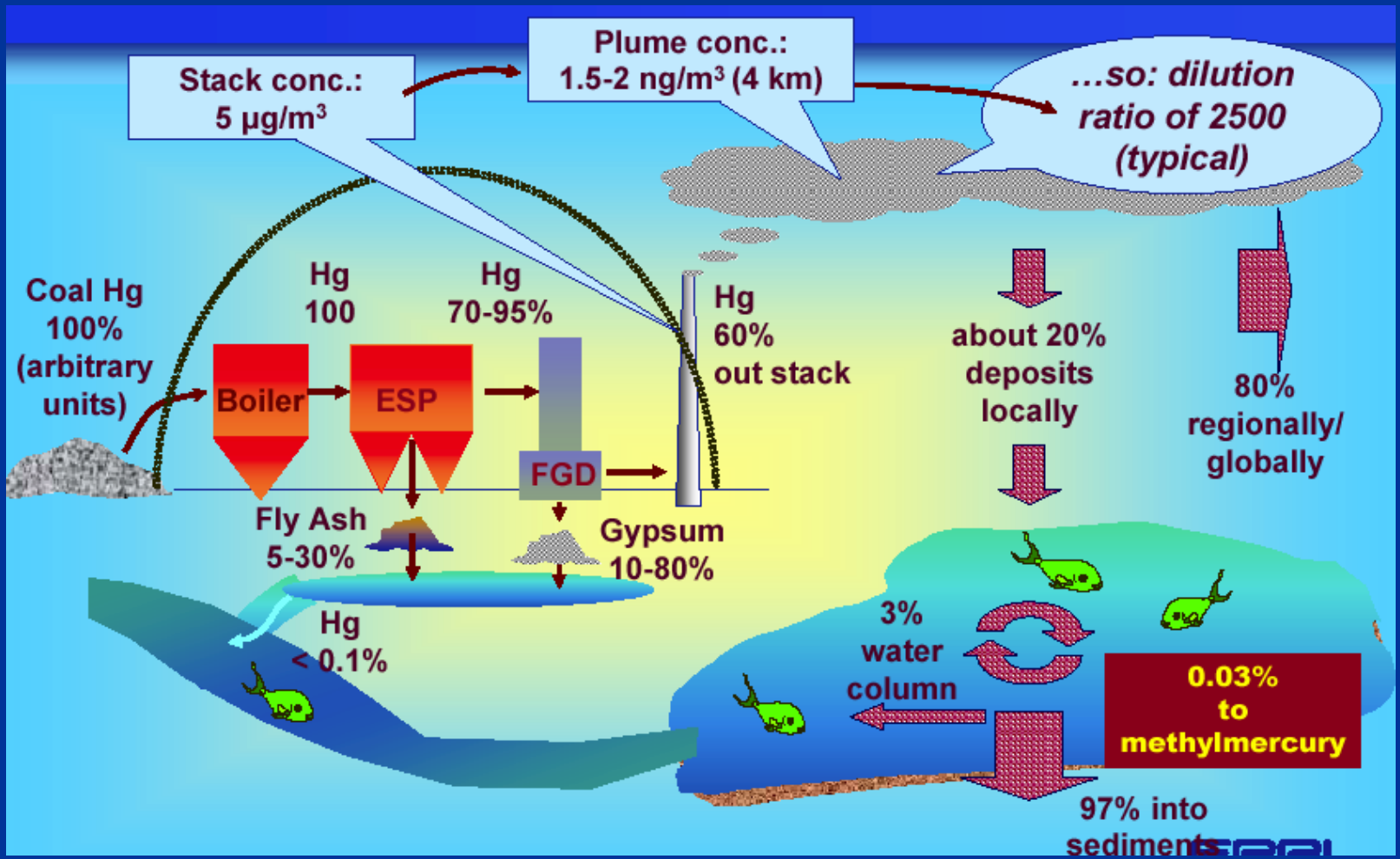
Atmospheric Chemistry of Mercury



Estimated Mercury Emission: (U.S. EPA (1996))



Fate of Mercury Emissions from Power Plant -from METAALICUS and Aircraft Measurements



Source: Leonard Levin, Valuing Externalities Workshop, Feb 2003

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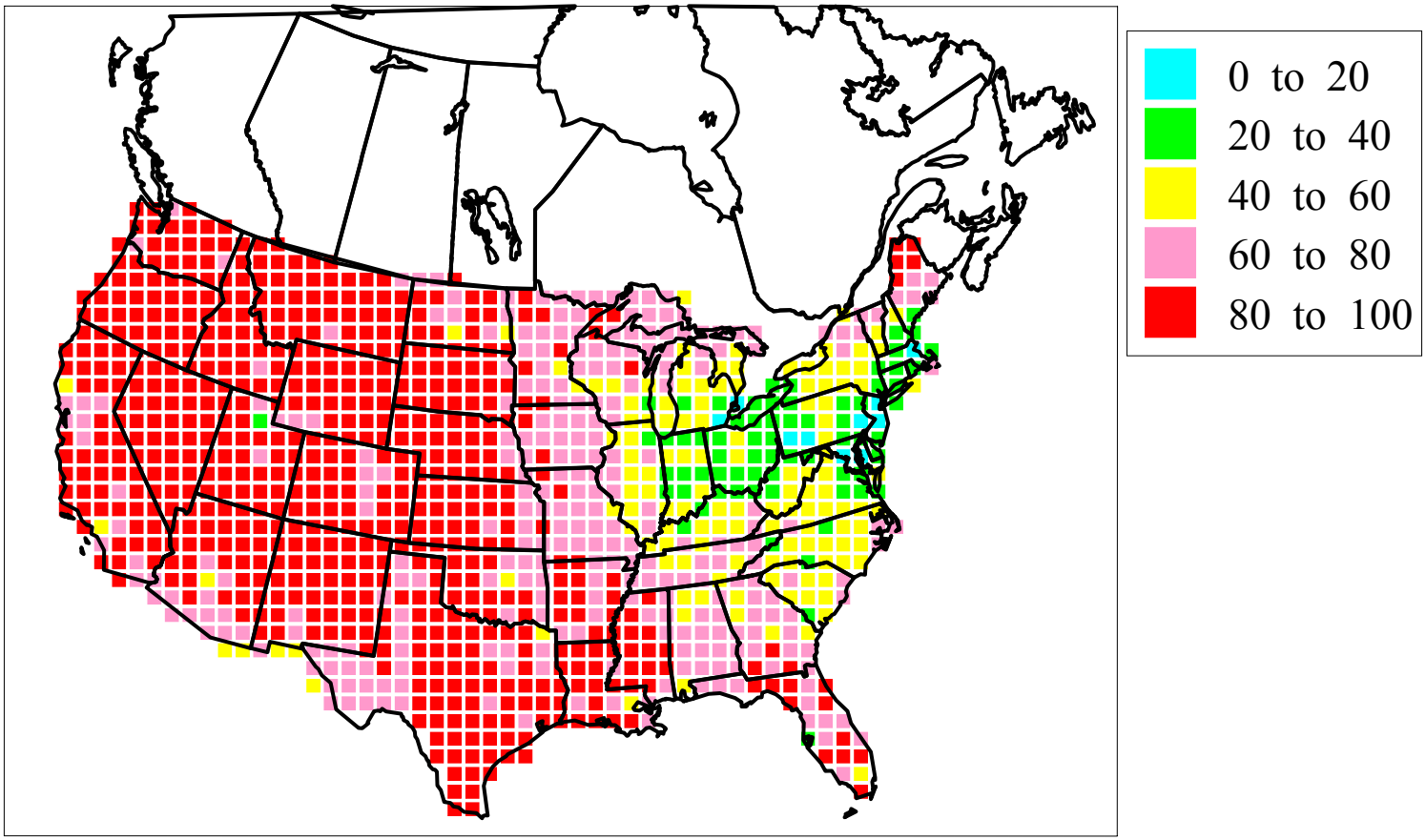
Contribution of the Global Background to Mercury Deposition (%)



Project Objectives

Quantitatively evaluate the emission, transport and deposition of mercury, arsenic and fine particulate matter in the Ohio River Valley region

- Ambient Monitoring
- Regional-Scale Modeling Analysis

Anticipated Benefits

Provide critical information for the development of relevant and cost effective control strategies

Monitoring Program

Objectives

- Measure and evaluate ambient and deposited concentrations of mercury, arsenic, and fine PM
- Validate model simulations
- Provide pre-regulatory data that can be used by the Ohio Valley industries to assess performance on multi-pollutant control systems

Sampling and Analytical - Overview

- **Sampling Program**
  - Continuous Sampers for $PM_{2.5,}$ $PM_{10,}$ SO_2, CO, NO_x and O_3
  - Continuous sampler for gas and particulate phase Hg
  - Filter based measurements: $PM_{2.5}$
  - Wet mercury deposition

- Sampling schedule as follows
  - 1 in 3 schedule for filter based samplers
  - Deposition sampling to be conducted on a weekly and event schedule
  - Gases, Tekran, TEOM, and weather to sample continuously or semi-continuously

- **Analytical Program**
  - Determine trace levels of mercury in deposition samples and $PM_{2.5}$ mass and composition (ions, trace elements, and carbon species)

Surface Air Monitoring

Ambient Monitoring Continued
Sampling - Gas and Particulate Phase Mercury

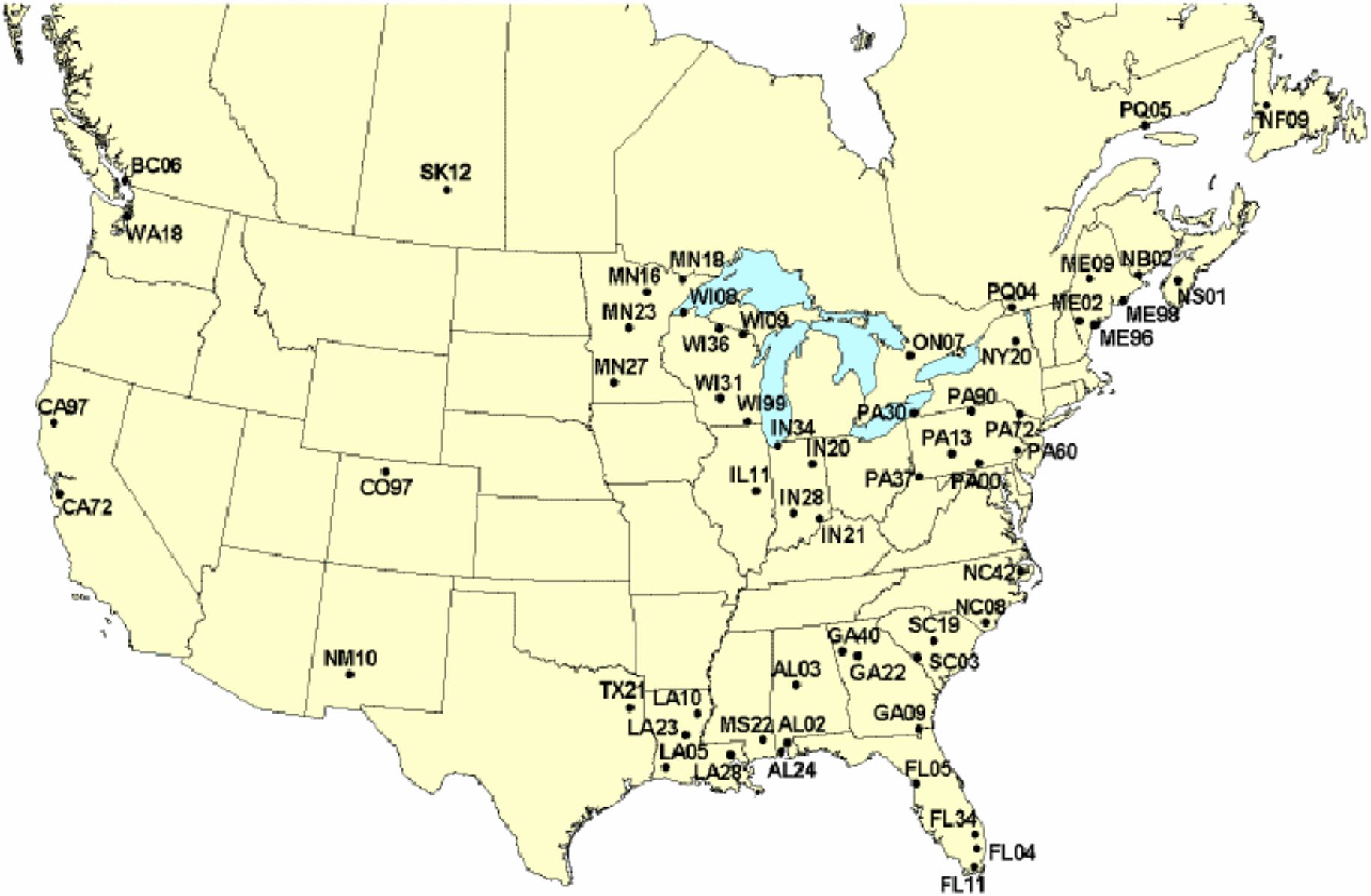
Photos courtesy of R.K. Steven's presentation at the Tekran Atmospheric Mercury Workshop, August 2002

Ambient Monitoring Continued
Mercury – Deposition Samples

- **Will collect weekly deposition samples plus additional "event" samples**

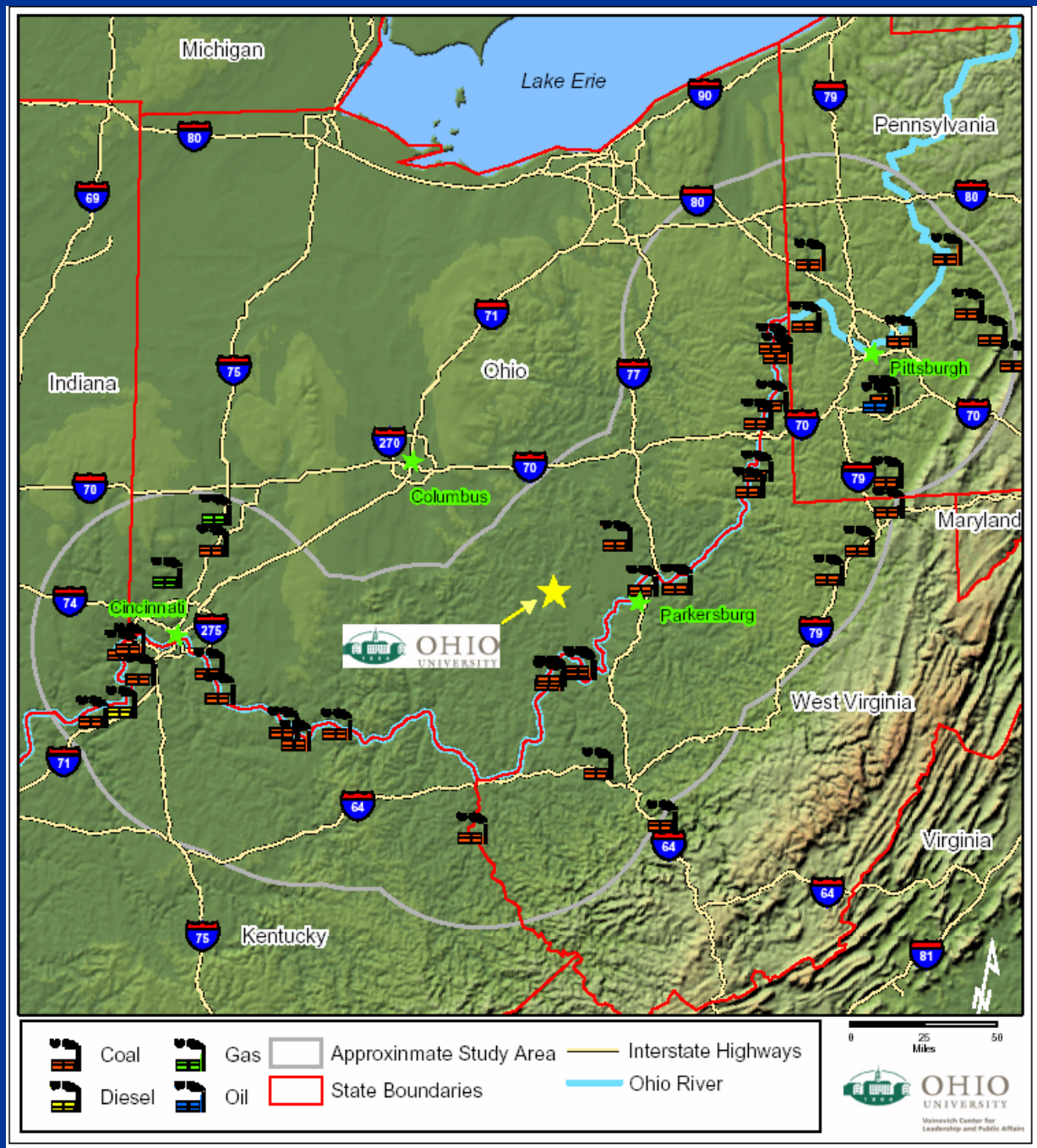
Photo courtesy of the National Atmospheric Deposition Network/Mercury Deposition Network website http://nadp.sws.uiuc.edu/mdn/ (Holbrook, PA)

National Atmospheric Deposition Program
Mercury Deposition Network

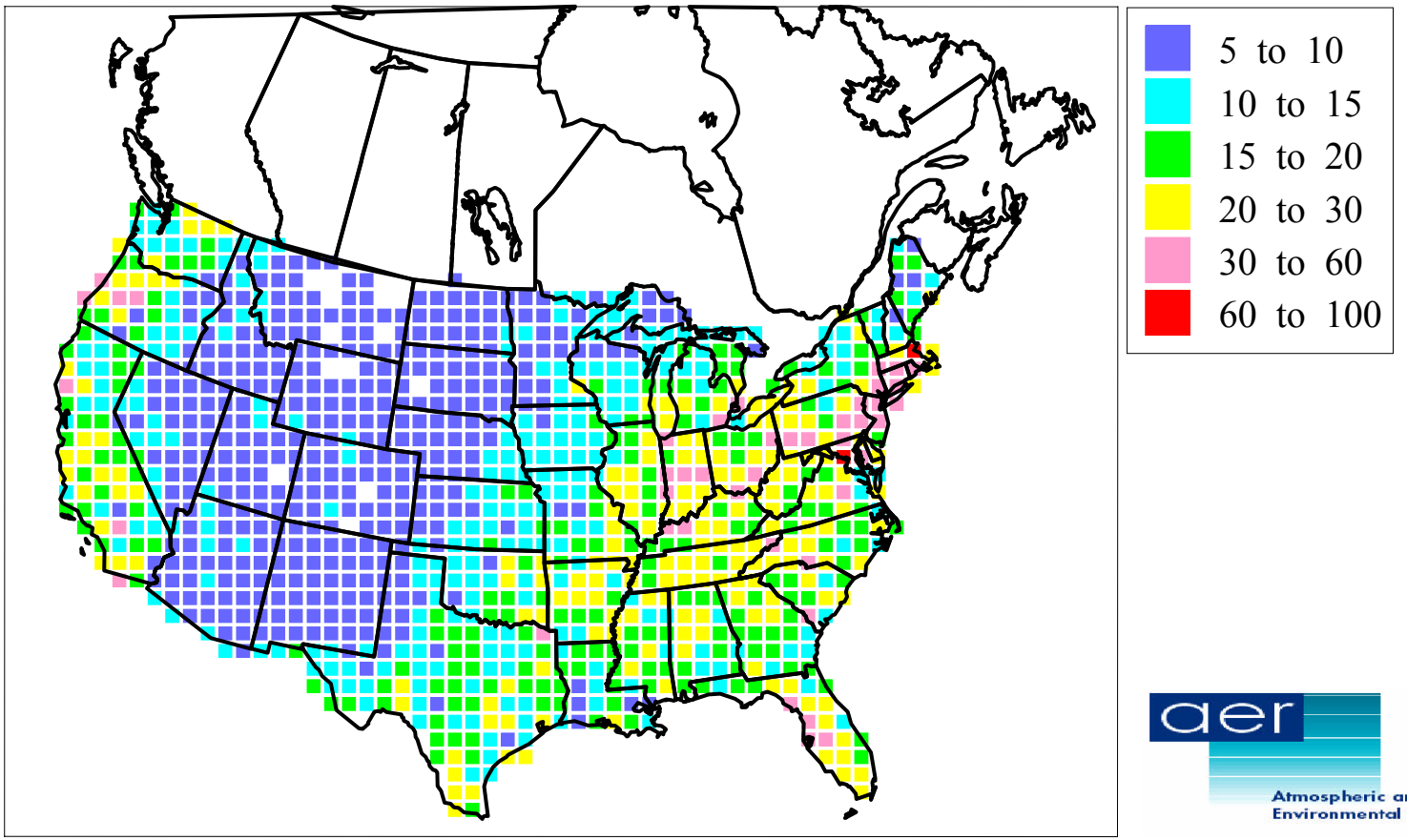


Analytical – Mercury Deposition and $PM_{2.5}$ Composition

- Determine trace levels of mercury in deposition samples and PM2.5 composition (including arsenic)
  - Mercury
    - Deposition Samples to be sent a NADP/MDN laboratory
      - Mercury determined by Cold Vapor Atomic Fluorescence
  - $PM_{2.5}$
    - Teflon filters from PM2.5 speciation sampler analyzed for mass, ions, and trace elements
      - Mass determined gravimetrically
      - Ions determined by Ion Chromatography
      - Trace Elements determined by Direct Reaction Cell Inductively Coupled Plasma Mass Spectroscopy
    - Quartz filter from PM2.5 speciation sampler analyzed for elemental, organic, and total carbon
      - Carbon determined by Thermal Optical Transmittance


Michigan
Lake Erie
Pennsylvania
Indiana
Ohio
Columbus
Pittsburgh
Cincinnati
Parkersburg
Maryland
West Virginia
Virginia
Kentucky
OHIO UNIVERSITY
Coal
Diesel
Gas
Oil
Approxinmate Study Area
State Boundaries
Interstate Highways
Ohio River
0
25
50
Miles
OHIO UNIVERSITY
Voinovich Center for Leadership and Public Affairs

Total Deposition of Mercury ($\mu g/m^2$-yr)



aer
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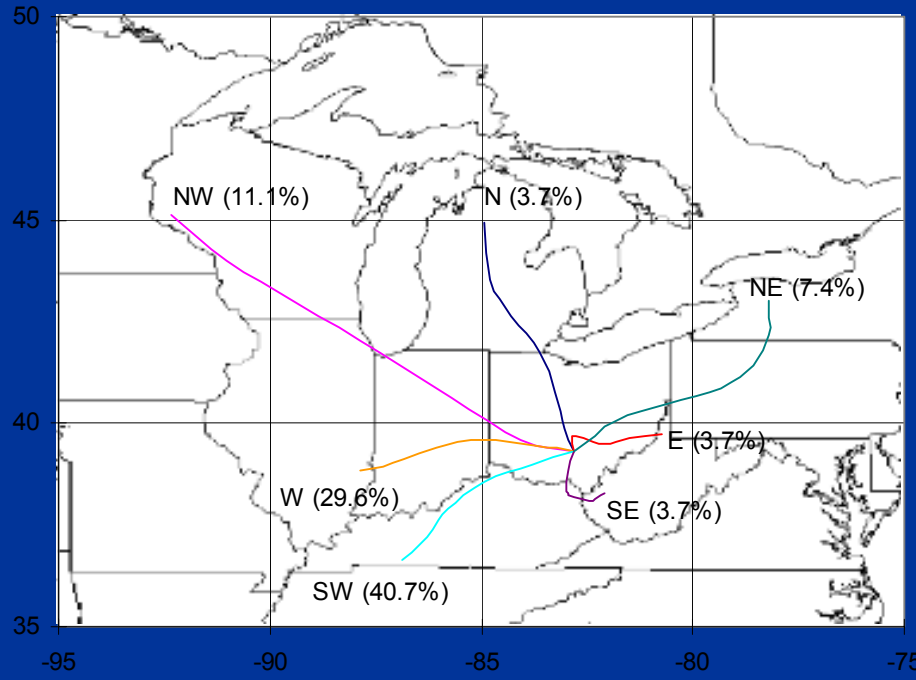
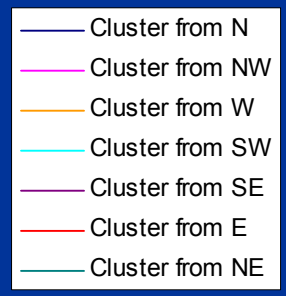
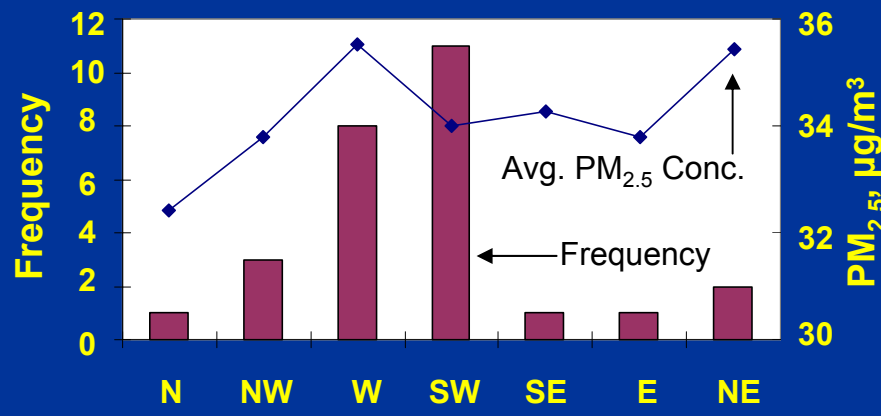
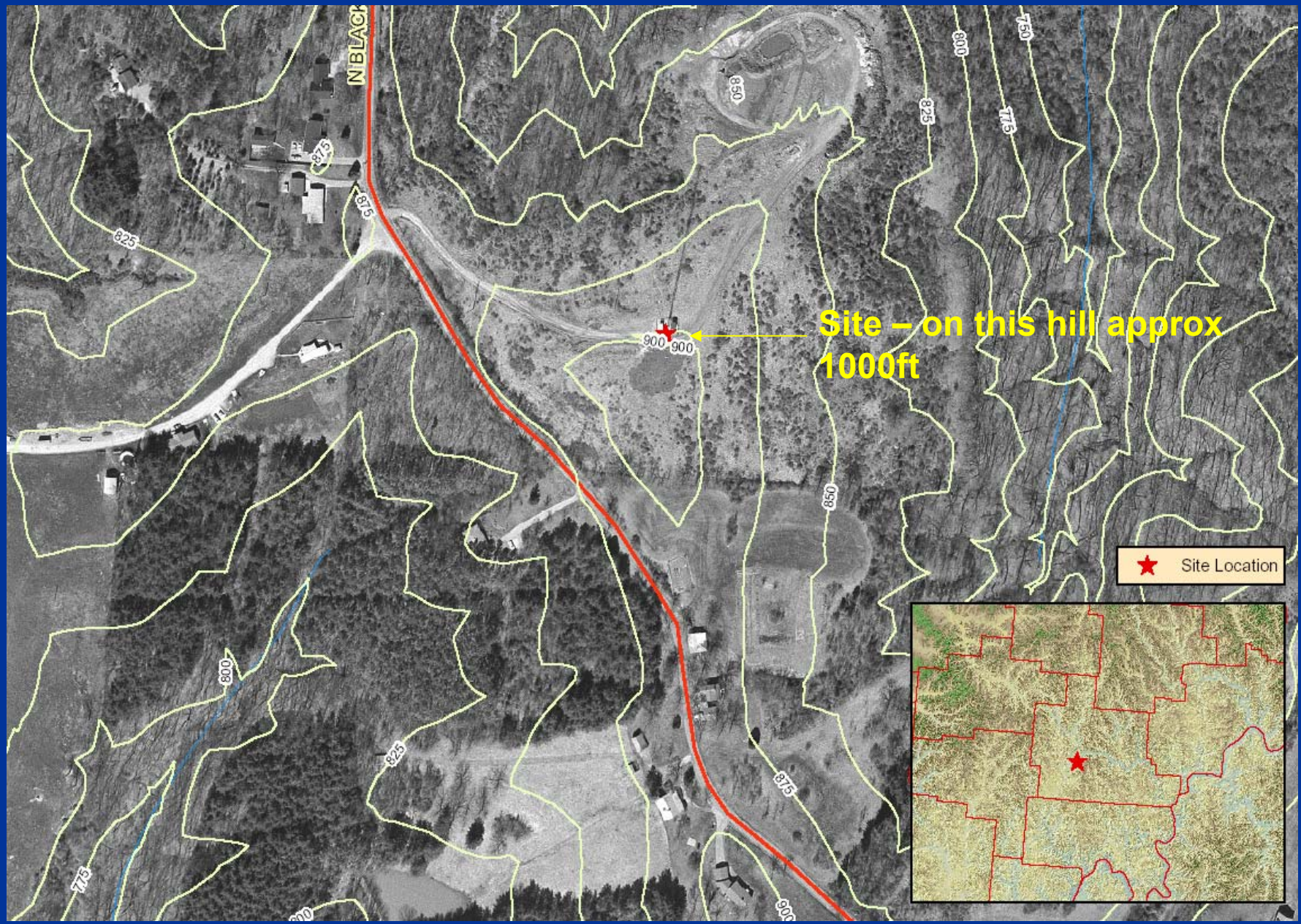
Cluster plot at Athens, 1999-2000

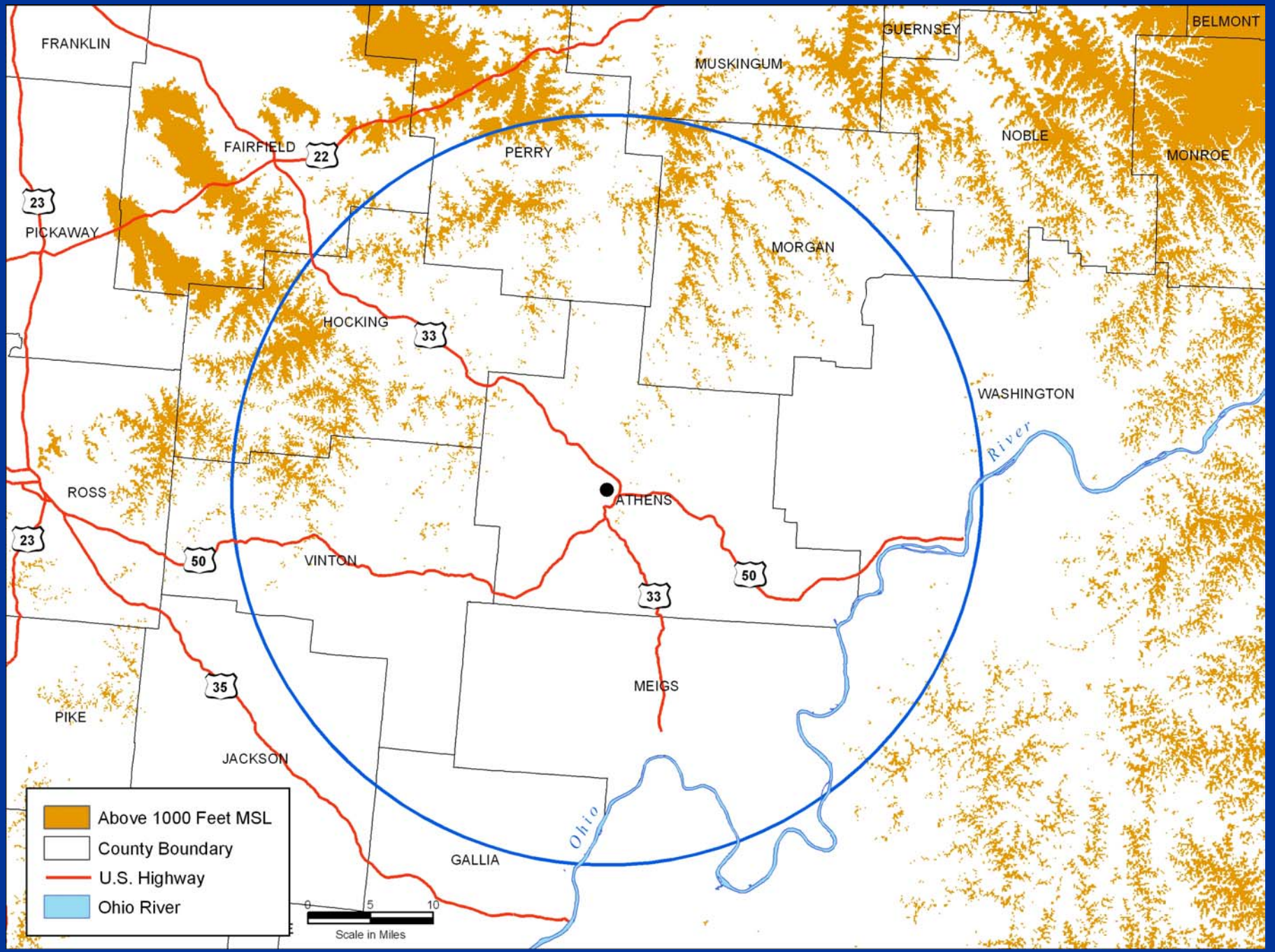




Frequencies and average $PM_{2.5}$ concentrations by cluster




Site – on this hill approx 1000ft
Site Location


FRANKLIN
FAIRFIELD
PICKAWAY
PERRY
MUSKINGUM
GUERNSEY
BELMONT
NOBLE
MONROE
MORGAN
HOCKING
WASHINGTON
ROSS
ATHENS
VINTON
MEIGS
PIKE
JACKSON
GALLIA
22
23
33
50
35
Ohio River
Above 1000 Feet MSL
County Boundary
U.S. Highway
Ohio River
0
5
10
Scale in Miles

Continental/Regional Scale Simulations

Simulations (Annual, Seasonal, Episodic)

1. Model Evaluation -Comparison of simulated and measured values
2. Evaluate the impacts of long range transport from regions outside the Ohio River Valley as well as biospheric recycling

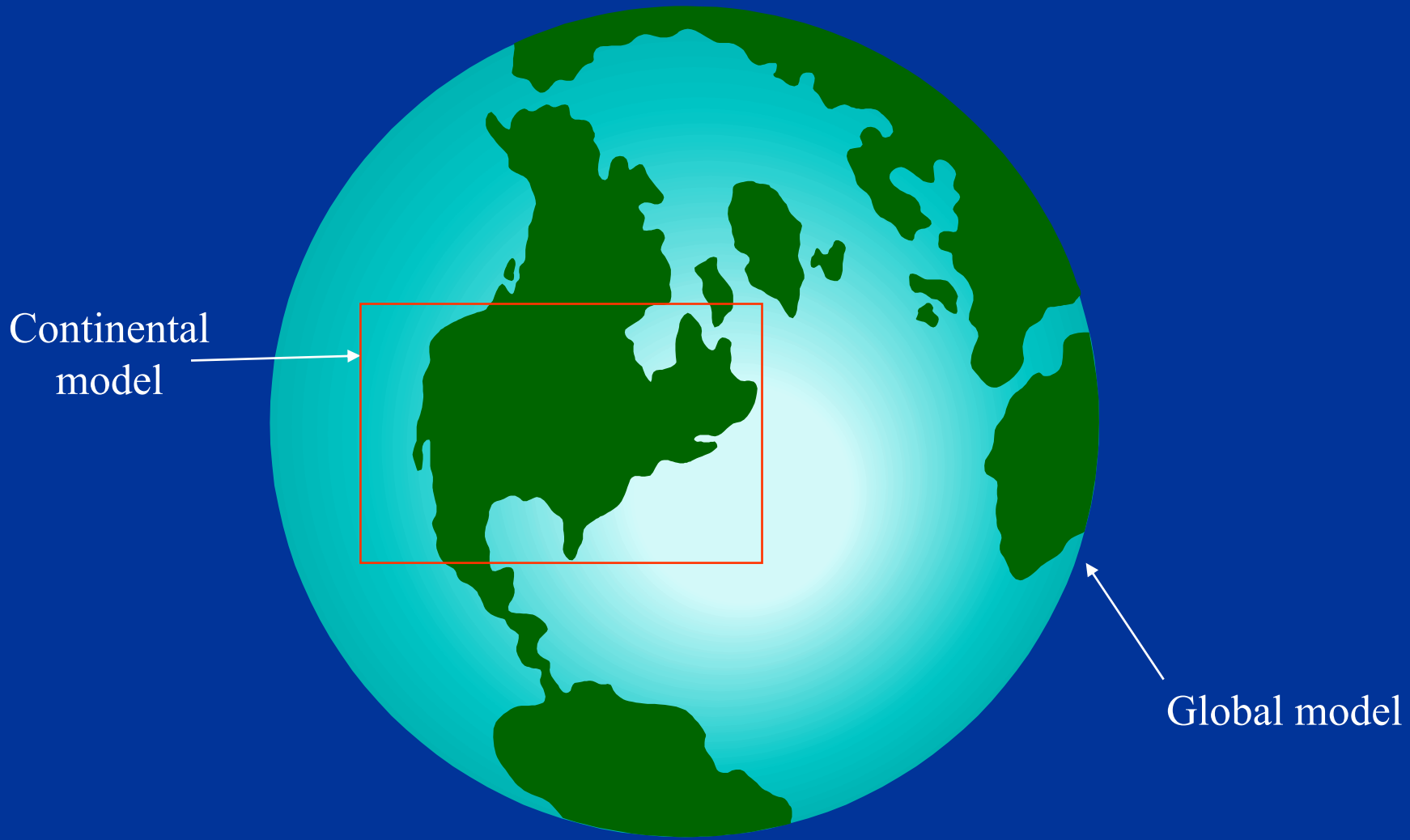
3. Series of simulations (matrix analysis) to evaluate the impact of various emission reduction strategies for the coal-fired power plants in the Ohio River Valley Region

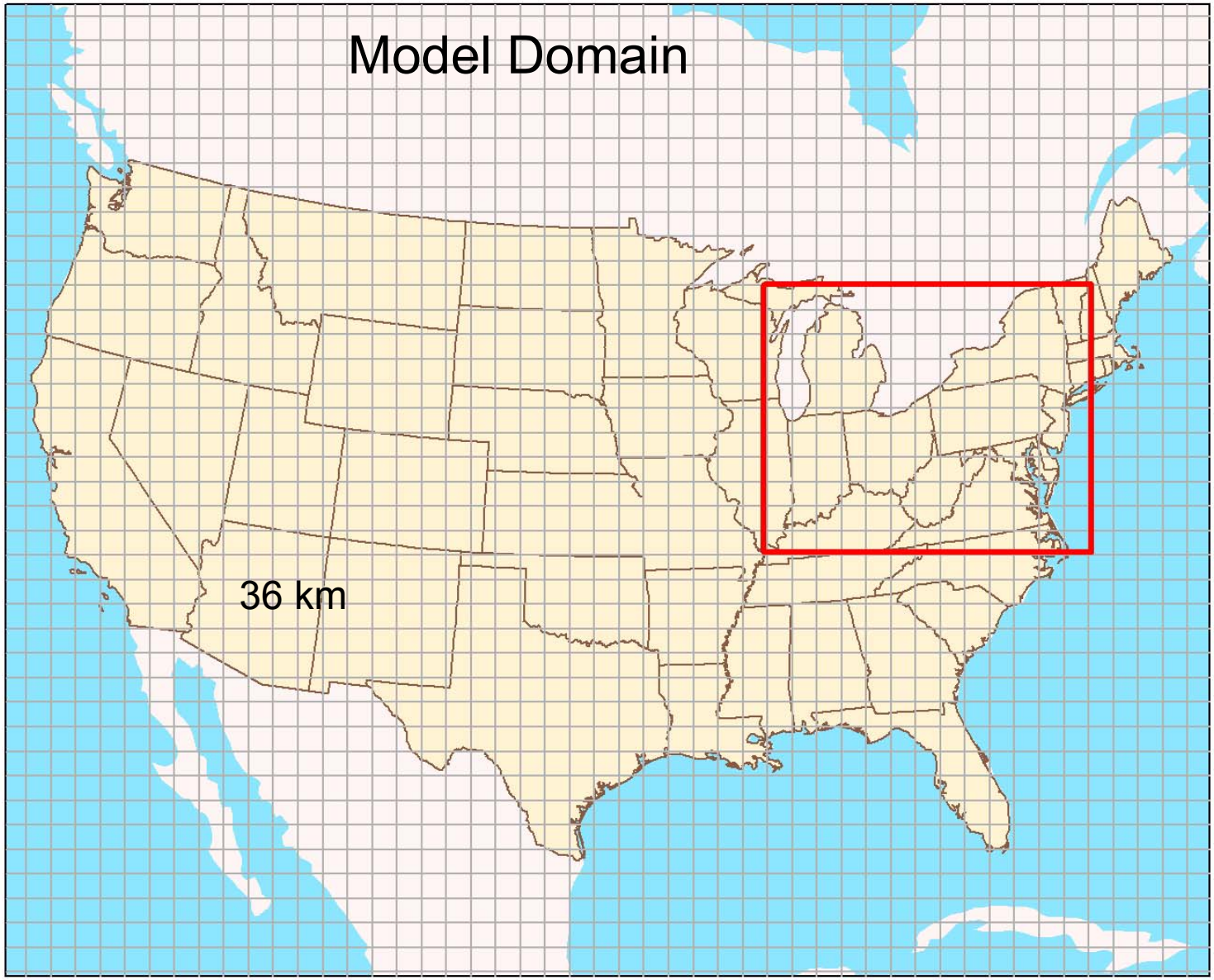
Modeling

Specifics

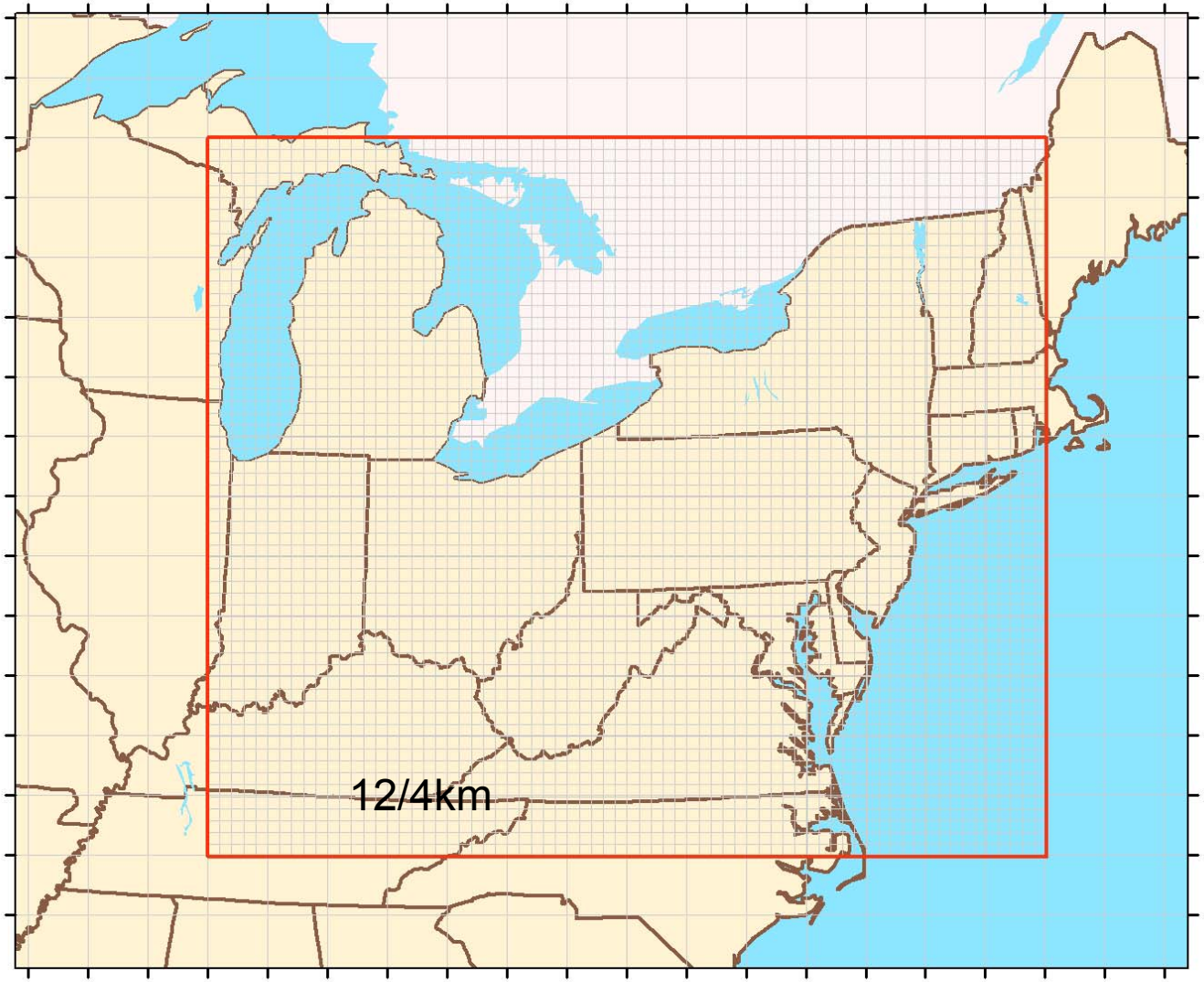
- Chemical Transport Model: Community Multi-scale Air Quality (CMAQ) model
- Meteorological Fields: MM5
- Domain: North America
  - Grid System (36/12/4km)

Multiscale Modeling of Atmospheric Mercury




Model Domain
36 km

Nested Grid System



Modeling

Specifics (continued)

- Emission Inventories
  - Mercury : AER (Seigneur et al., 2001)
    - » Includes power plant emissions from ICR
  - Arsenic The National Emissions Inventory (NEI) 1999 includes HAPs
  - U.S. EPA's 1996 Interim Emission Inventories

EI Enhancements:

NETL Sponsored Source Testing (Consol)

NETL Sponsored Pittsburgh Air Quality Study

Review Data from Mexico

Development of a Decision Support Tool

- Series of model runs will be conducted to evaluate the sensitivity of point sources to deposition patterns in the region.

- Develop a matrix that will be coupled with a GIS interface to provide a detailed spatial analysis of the source-receptor relationship

Hg and As Modeling in Ohio River Valley

Project Schedule